The value of $ETCO_2$ measurement for COPD patients in the emergency department

Mutlu Kartal[a], Erkan Goksu[a], Oktay Eray[a], Soner Isik[a], Ali Vefa Sayrac[a], Ozlem Erken Yigit[a] and Stephan Rinnert[b]

We aimed to determine the value of sidestream end-tidal carbon dioxide (SS-$ETCO_2$) measurement in patients with chronic obstructive pulmonary disease (COPD) in the emergency department. Cross-sectional associations between $ETCO_2$ and $PaCO_2$ were examined in the study. This prospective cross-sectional study has been carried out over a 3-month period in a tertiary care university hospital emergency department with an annual census of 75 000 visits. During the study period, simultaneous SS-$ETCO_2$ measurement using a Medlab Cap 10 sidestream capnograph was performed on every COPD patient requiring arterial blood gas analysis. The demographics, diagnosis, vital signs, laboratory test results and clinical outcomes of the patients were recorded. SS-$ETCO_2$ measurement and arterial blood gas analysis were carried out on 118 patients. Mean arterial PCO_2 levels were 43.24 ± 14.73 and mean ETCO2 levels were 34.23 ± 10.86 mmHg. Agreement between PCO_2 and $ETCO_2$ measurements was 8.4 mmHg and a precision of 11.1 mmHg. As there is only a moderate correlation between PCO_2 and $ETCO_2$ levels in COPD patients, $ETCO_2$ measurement should not be considered as a part of the decision-making process to predict $PaCO_2$ level in COPD patients. *European Journal of Emergency Medicine* 18:9–12 © 2011 Wolters Kluwer Health | Lippincott Williams & Wilkins.

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[a]Department of Emergency Medicine, School of Medicine, Akdeniz University, Antalya, Turkey and [b]Department of Emergency Medicine, SUNY Downstate/Kings County Hospital, Brooklyn, New York, USA

Correspondence to Erkan Goksu, Department of Emergency Medicine, School of Medicine, Akdeniz University, Arapsuyu, Antalya 07059, Turkey
Tel: +90 242 2492235; fax: +90 242 2274490;
e-mail: erkangoksu@akdeniz.edu.tr

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Introduction

Chronic obstructive pulmonary disease (COPD) patients commonly present to the emergency department (ED) with exacerbation of the disease. Oxygenation and ventilation status of these patients need close and continuous observation. Arterial blood gas (ABG) analysis provides accurate information of patient's ventilation status but the procedure is time consuming, invasive, painful and in some patients, it needs multiple punctures. The procedure can have potential risks not only for the patients but also for healthcare providers because of needle sticks. Alternative methods to replace ABG analysis such as oxyhemoglobin saturation have been used in patients with respiratory distress [1]. Although oxyhemoglobin saturation can give accurate information about oxygenation, it does not reflect the patient's $PaCO_2$ level and thus ventilation status. There are some studies in the literature looking at noninvasive end-tidal carbon dioxide ($ETCO_2$) measurement [2–4] as an alternative to ABG's in the pediatric population suspected of diabetic ketoacidosis and dehydration.

$ETCO_2$ has also been studied in confirmation of endotracheal tube positioning in the operation room and in EDs [5] where low $ETCO_2$ values may indicate incorrect tube position during the intubation process. The results of these studies have encouraged clinicians to use noninvasive $ETCO_2$ measurement in the ED. Sidestream $ETCO_2$ (SS-$ETCO_2$) has been found to be closely correlated to arterial $PaCO_2$, especially in hemodynamically stable patients with normal lung function [6,7].

As it is instantaneous, noninvasive and easily available, SS-$ETCO_2$ can be a suitable tool in the ED setting. However, to date $ETCO_2$ has not been completely validated for COPD patients. The aim of this study was to investigate the relation between $PaCO_2$ and SS-$ETCO_2$ measurement in patients with COPD presenting to the ED with acute disease exacerbation.

Methods

Study design and setting

This prospective cross-sectional study has been carried out over a 3-month period in a tertiary care university hospital ED with an annual census of 75 000 patients. The study was approved by the hospital's institutional review board. Informed consent was obtained from all participants. The study group consisted of a prospectively gathered convenience cohort of nonintubated ED patients with acute COPD exacerbation requiring ABG analysis.

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Consecutive COPD patients over the age of 18 years necessitating ABG analysis were recruited into the study. Diagnosis of COPD was derived from medical records of patients. Diagnosis of acute exacerbation was based on the presence of any combination of the following symptoms: purulence of sputum, increased dyspnea, or increased production of sputum. In order not to miss patients during the study period, the process was achieved through an agreement with the laboratory that only an ABG sample accompanied with a study inclusion form would be studied. ABG's were drawn in patients with suspected hypoxia, hypercarbia and severe respiratory distress. Simultaneously those patients' $ETCO_2$ level was measured using Medlab cap 10-sidestream capnograph (Medlab medizinische Diagnosegeräte GmbH, Karlsruhe, Germany). ABG analysis results were available within 10 min. All emergency residents and physicians had in-service training about the standard usage of the capnograph and were informed about the study protocol.

Data collected

Besides SS-$ETCO_2$ and ABG measurements the following demographic parameters were recorded: age, sex, blood pressure, respiratory rate, pulse rate, body temperature, partial oxygen and carbon dioxide saturation and pressure, final diagnosis, unanticipated return visit and death. Patients who did not want to participate in the study were excluded.

Outcome of interest

Cross-sectional associations between $ETCO_2$ and $PaCO_2$ were examined in our analysis.

Analysis

The study data were analyzed using SPSS 15.00 for windows (SPSS Inc., Chicago, Illinois, USA) and Medcalc 11.1 software (MedCalc Software bvba, Mariakerke, Belgium). The parametric comparison of two groups was performed by Student's-*t* test and categorical data with χ^2 test. The linear correlation between the two groups was performed by Pearson's correlation coefficient, and Bland–Altman analysis was used to determine the agreement between the two methods. The normality analysis was performed by the Kolmogorov–Smirnov test. All of the hypothesis was constructed two-tailed and an α critical value of 0.05 was accepted as significant.

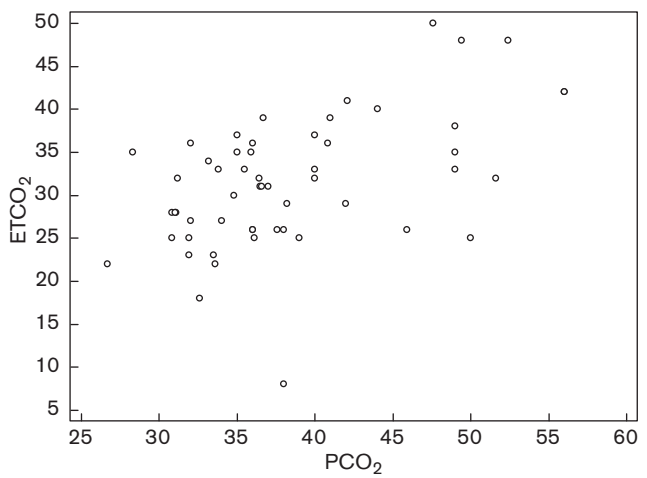
Results

During the study period, physicians ordered 129 ABG sampling in patients with COPD exacerbation. Four patients with incorrect capnograph usage, two patients who did not give informed consent and five patients who were lost to follow-up were excluded from the study. Data from the remaining 118 patients were analyzed. Sixty-three (53%) of 118 patients were admitted and the remainder 55 patients were discharged from the ED. Death occurred in six patients in the admitted group and two patients in the discharged group and unanticipated return visit occurred in nine patients.

Table 1 Baseline characteristics of study participants

Variable	All patients (n=118)	Group 1 (returned) (n=9)	Group 2 (no return) (n=46)	P
Age (year)	69 ± 12	68 ± 16	69 ± 13	0.836
Sex (male/female)	69/49	5/4	31/15	0.373
Mean systolic blood pressure	138.9 ± 21	144.5 ± 21	137.8 ± 20.8	0.378
Mean diastolic blood pressure	76.1 ± 14.7	83 ± 11	73.5 ± 16	0.09
Mean respiratory rate	25 ± 7	24 ± 6	24 ± 7	0.964
Mean O_2 saturation (%)	87 ± 11	92 ± 4	90.7 ± 10	0.725
Mean pulse/min	101 ± 22	106 ± 24	99 ± 21	0.397

Fig. 1



Scatter plot of end-tidal carbon dioxide ($ETCO_2$) versus PCO_2.

Forty-nine (41%) of 118 patients were female and the mean age was 69 ± 12. Patient characteristics are shown in Table 1. The mean value of $ETCO_2$ and $PaCO_2$ were 33.7 ± 10.45 (min 8 max 74) and 42.2 ± 13.5 (26.5–113), respectively. Scatter plot of $ETCO_2$ versus PCO_2 levels is shown in Fig. 1. Agreement between PCO_2 and $ETCO_2$ measurements of 8.4 mmHg and a precision of 11.1 mmHg. The limit of agreement between ETCO2 and PCO2 is shown in Fig. 2.

Discussion

Our results show that SS-$ETCO_2$ measurements do not reflect $PaCO_2$ in COPD patients in the ED. We therefore conclude that $ETCO_2$ measurement may not be a useful adjunct in predicting hypercarbia in COPD patients.

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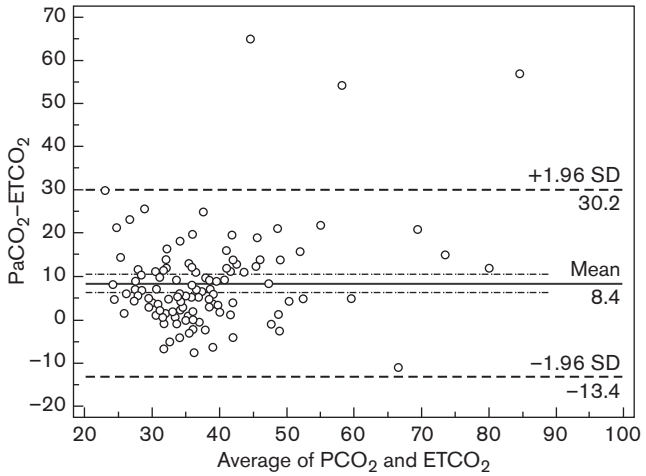
Fig. 2



Modified Bland–Altman plot illustrating the agreement between end-tidal carbon dioxide ($ETCO_2$) and $PaCO_2$.

In earlier studies, $ETCO_2$ has shown good agreement with $PaCO_2$ during anesthesia and in critical care settings in patients with normal lung functions [8]. Patients with normal lung function have $ETCO_2$ values between 35–45 mmHg and a narrow $ETCO_2$–$PaCO_2$ gradient (0–5 mmHg) because of alveolar dead space. Disease causing ventilation-perfusion mismatch and abnormal lung function may increase $ETCO_2$–$PaCO_2$ gradient because of increased dead space [9].

In contrast to our results, some investigators found a positive correlation between $ETCO_2$ and $PaCO_2$ levels in patients with respiratory distress [10]. The patient population of the relevant study included both COPD ($n = 20$) and heart failure ($n = 50$) patients presenting with respiratory distress. There are two other studies in the literature with small sample sizes comparing $ETCO_2$ and $PaCO_2$ levels in similar heterogenous populations including patients with or without respiratory distress [11,12]. The pathophysiology of diseases is different in these patient groups. As our study population is more homogenous when comparing the ones above, we believe the result of our study is more reliable.

A prospective cohort study in patients with acute severe asthma exacerbation showed a positive concordance between $ETCO_2$ measured by capnography and arterial $PaCO_2$ [13]. In contrast to aforementioned study, the correlation of $ETCO_2$ and $PaCO_2$ in our study was moderate. There may be several reasons for this discrepancy. On account of increased respiratory rates and dead space in COPD patients, the obstructive disease can result in a delay in the maximum alveolar concentration of CO_2 reaching the cannula and may give lower $ETCO_2$ values when compared with $PaCO_2$. This may falsely increase the $PaCO_2$–$ETCO_2$ gradient [9]. In the study of Langhan *et al.* [14] they have studied $ETCO_2$ values to assess the severity of asthma exacerbations and found that patients with asthma exacerbations had lower $ETCO_2$ values than age-matched controls.

In a recent retrospective study, Moses *et al.* [15] studied the utility of ETCO2 monitoring in the assessment and management of nonintubated pediatric patients with moderate-to-severe respiratory distress and found that $ETCO_2$ is highly correlated with venous partial CO2 in nonintubated pediatric patients. In their study, they have included the patients with the diagnosis of asthma, bronchiolitis, or pneumonia and excluded the patients with chronic pulmonary disease (cystic fibrosis, chronic lung disease), cardiac disease or poor tissue perfusion. They have carried out the study in the intermediate care unit and ABG and $ETCO_2$ measurement were performed within 10 min. The difference in the pathophysiology of diseases and the patient population studied may be the reason for this discrepancy.

Limitation

$PaCO_2$ values were not corrected for temperature.

Conclusion

As there is a poor agreement between $ETCO_2$ and ABG measurement, $ETCO_2$ cannot be used as a substitute for $PaCO_2$ in clinical assessment of patients with COPD. To make clinical decision in this patient population other parameters such as oxygen saturation and ABG analysis should be instituted in an appropriate clinical setting.

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